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FLOOD FREQUENCY ANALYSIS OF PRAKASAM BARRAGE RESERVOIR KRISHNA DISTRICT, ANDHRA PRADESH USING WEIBULL, GRINGORTEN AND L-MOMENTS FORMULA

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ABSTRACT

The structure of the Prakasam barrage stretches 1223.5 m across the Krishna River connecting Krishna and Guntur districts with geographical co-ordinates $16°30^{1}23^{11}$ N latitude $80°36^{1}17^{11}$ E longitude. The reservoir has been attacked by the number of floods during the past and present This paper presents a frequency distribution study on maximum monthly flood data in Krishna River at Prakasam Barrage using the probability plot and flood – frequency curves by Gumbel distribution using three different plotting position formulas which are weibull, Gringorten and L-moment for 30 years (1982-83 to 2012-13). It is found that L- Moments method is best fit for flood frequency curves, with some limitations which are good for small samples of data, when compare with gringorten and weibull methods. The following study can be used by planning and designing engineers for deciding the dimension of hydraulic structures such as bridges, dams, canals, levees, and spillways etc. This study can be further extended into preparation of flood forecasting techniques and flood inundation maps for Krishna River.

KEYWORDS: Flood Frequency, Gringorten, Gumbel Distribution, L-Moments, Weibull

INTRODUCTION

Flood hazards are world-wide considered as one of the most significant natural disasters in terms of human impact and economic losses One method of decreasing flood damages and economic losses is to use flood frequency analysis for determining efficient designs of hydraulic structures. Estimation of Peak Flood Magnitude for a desired return period is often required for planning, design and management of hydraulic and other structures in a region. Flood frequency analysis is used to predict design floods for sites along a river. The technique involves using observed annual peak flow discharge data to calculate statistical information such as mean values, standard deviations, skewness, and recurrence intervals. These statistical data are then used to construct frequency distributions, which are graphs and tables that tell the likelihood of various discharges as a function of recurrence interval or exceedence probability. The main scope of the work is to determine the magnitude and flood frequency analysis, using the Gumbel distribution by Weibull formula, Gringorten formula and L-moments formula for the Prakasam barrage.

NATURE OF STUDY

Prakasam Barrage was constructed across the River, Krishna near Vijayawada city in Andhra Pradesh on upstream side of the breached and damaged century old anicut. It is a Regulator built on sand foundations, combined with a road bridge of 24 Ft for two lane traffic with 5 ft wide foot paths on either side, connecting Chennai-Kolkata Highway.

The Barrage was necessiated to be constructed to meet the demands of the increased irrigation ayacut of 13 Lakhs acres. The objectives of the study are to assess the relative performance of the currently recommended flood frequency analysis method with some of the recently developed techniques. To evaluate the magnitude and flood frequency of the Prakasam Barrage reservoir in Krishna District. To determine the return period and recurrence interval of the discharge in Krishna district by using Weibull Method, Gringorten Method and L-Moment Method. To Provide a scientific framework for assessing the influence of environmental change on the future flood frequency characteristics. The location map of the study area is shown in figure 1

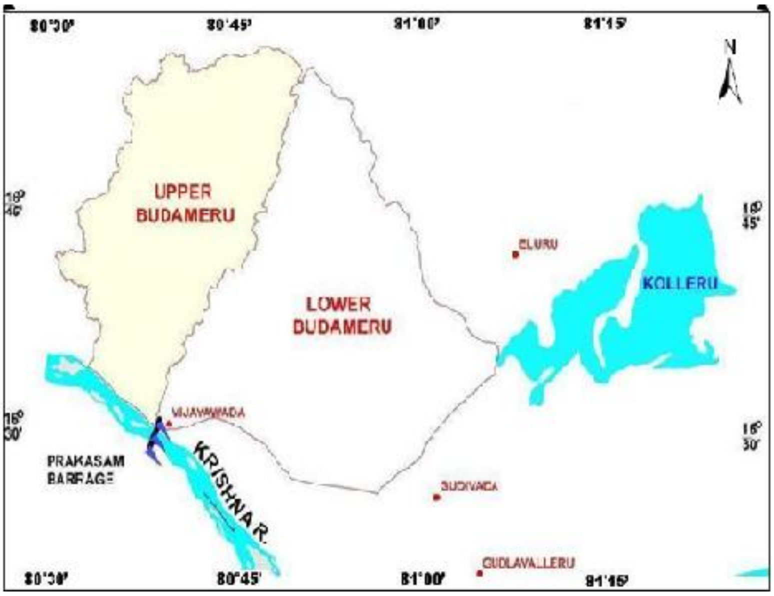

Figure 1: Location Map of Study Area

METHODOLOGY

The study has carried by collecting inflow data from the reservoir from the E.E, Dept of Irrigation of Krishna district. The estimation of flood frequency analysis in this region has done by using the application of gumbel distribution with weibull formula, gringorten formula and L-moment method. It is hoped that the findings from this study could contribute to the knowledge of the application of gumbel distribution in flood frequency study in Krishna district. The data collected on various parameters as depicted above, is analyzed and various indices w.r.t. to flood inflow data in the study area are calculated.

After knowing annual peak flood inflow data of Prakasam Barrage discharge then the annual extreme series are arranged in descending order of magnitude. Then the arithmetic mean of annual flood is calculated (MAF). Then the plotting position of each sample is determined. In this study, mainly focus on the gumbel distribution with three plotting position formulas (Weibull Distribution, Gringorten Method and L-moment Method) which applied to data for analysis of flood

WEIBULL METHOD

The probability density function of a Weibull random variable is

$$f(x;\lambda,k) = \begin{cases} \frac{k}{\lambda}\left(\frac{x}{\lambda}\right)^{k-1} e^{-(x/\lambda)^k} & x \geq 0, \\ 0 & x < 0, \end{cases}$$

where $k > 0$ is the shape parameter and $\lambda > 0$ is the *scale parameter* of the distribution. Its complementary cumulative distribution function is a stretched exponential function. The Weibull distribution is related to a number of other probability distributions; in particular, it interpolates between the exponential distribution ($k = 1$) and the Rayleigh distribution ($k = 2$).

GRINGORTEN METHOD

Gringorten (1971) obtained an estimate of the conditional probability of an event through use of the bivariate normal frequencies and persistence of the event. The Gringorten plotting position for the *r*th ranked (from largest to smallest) datum from a sample of size *n* is the quotient:

$$\frac{r - 0.44}{n + 0.12}.$$

L- MOMENT METHOD

The approach based on the theory of L-moments was firstly proposed by Wallis, (1989) then developed by Hosking and Wallis, (1997). L-moments are summary statistics for probability distributions and data samples. They are analogous to ordinary moments, because of providing measures of location, dispersion, skewness, kurtosis, and other aspects of the shape of probability distributions or data samples, but are computed from linear combinations of the ordered data values. L-moments may be applied in four steps of the regional frequency analysis including screening of the data, identification of homogenous regions, choice of a frequency distribution and estimation of the frequency distribution (Hosking and Wallis, 1997). The main advantages of L-moments over conventional moments are that they are able to characterize a wider range of distributions, and (when estimated from a sample) are less subject to bias in estimation and more robust to the presence of outliers in the data. The latter is because ordinary moments unlike L-moments require involution of the data which causes disproportionate weight to be given to the outlying values. Standard errors are obtained from a re-estimated model with no intercept. We note that estimating the cross-section specific constant regression model with a large number of cross-section units is time consuming, and may result in estimates that are less accurate than those obtained using the fixed-effects option.

DISCUSSIONS

The magnitude and flood frequency analysis of the Prakasam barrage using Gumbel distribution by Weibull formula, Gringorten formula and L-moments formula, the results obtained from the calculations are shown in below (table-1) utilized to produce the probability plot and flood frequency curve.. The out come of the analysis clearly reveals the good capability of the Gumbel distribution function to predict river flood magnitudes. By using three plotting position methods we can observe the various differences in flood frequency curves of study reservoir when they are plotted in graph see figure: 2, 3, and 4.

Table 1: Results of Probability Methods for Prakasam Barrage Reservoir

Year	Weibull			Gringorten			L-Moment			
	Q_T/MAF	T_W	Y_W	Q_T/MAF	T_G	Y_G	QT/MAF	Y_{LM}	F_X	T_{LM}
1982-1983	5.83	32.00	3.45	5.83	50.00	3.90	5.83	5.69	1.00	9.00
1983-1985	2.56	16.00	2.74	2.56	19.23	2.93	2.56	2.10	0.88	8.54
1984-1985	2.33	10.67	2.32	2.33	11.91	2.43	2.33	1.85	0.86	6.25
1985-1986	2.19	8.00	2.01	2.19	8.62	2.09	2.19	1.69	0.83	5.19
1986-1987	2.15	6.40	1.77	2.15	6.76	1.83	2.15	1.66	0.83	4.98
1987-1988	2.15	5.33	1.57	2.15	5.56	1.62	2.15	1.65	0.83	4.97
1988-1989	2.12	4.57	1.40	2.12	4.72	1.43	2.12	1.62	0.82	4.77
1989-1990	1.84	4.00	1.25	1.84	4.10	1.27	1.84	1.31	0.76	3.51
1990-1991	1.70	3.56	1.11	1.70	3.62	1.13	1.70	1.16	0.73	3.08
1991-1992	1.59	3.20	0.98	1.59	3.25	1.00	1.59	1.04	0.70	2.78
1992-1993	1.31	2.91	0.87	1.31	2.94	0.88	1.31	0.73	0.62	2.21
1993-1994	1.17	2.67	0.76	1.17	2.69	0.77	1.17	0.58	0.57	1.99
1994-1995	1.15	2.46	0.65	1.15	2.48	0.66	1.15	0.56	0.56	1.97
1995-1996	1.12	2.29	0.55	1.12	2.29	0.56	1.12	0.53	0.55	1.94
1996-1997	0.94	2.13	0.46	0.94	2.14	0.46	0.94	0.32	0.48	1.72
1997-1998	0.89	2.00	0.37	0.89	2.00	0.37	0.89	0.27	0.47	1.68
1998-1999	0.79	1.88	0.28	0.79	1.88	0.28	0.79	0.16	0.43	1.59
1999-2000	0.76	1.78	0.19	0.76	1.77	0.19	0.76	0.12	0.41	1.56
2000-2001	0.59	1.68	0.10	0.59	1.68	0.10	0.59	-0.06	0.34	1.44
2001-2002	0.57	1.60	0.02	0.57	1.59	0.01	0.57	-0.08	0.34	1.43
2002-2003	0.53	1.52	-0.07	0.53	1.52	-0.08	0.53	-0.13	0.32	1.41
2003-2004	0.39	1.46	-0.15	0.39	1.45	-0.16	0.39	-0.28	0.27	1.33
2004-2005	0.38	1.39	-0.24	0.38	1.38	-0.25	0.38	-0.29	0.26	1.33
2005-2006	0.31	1.33	-0.33	0.31	1.32	-0.34	0.31	-0.37	0.24	1.30
2006-2007	0.27	1.28	-0.42	0.27	1.27	-0.44	0.27	-0.41	0.22	1.28
2007-2008	0.24	1.23	-0.52	0.24	1.22	-0.54	0.24	-0.45	0.21	1.27
2008-2009	0.22	1.19	-0.62	0.22	1.17	-0.65	0.22	-0.46	0.20	1.26
2009-2010	0.11	1.14	-0.73	0.11	1.13	-0.77	0.11	-0.58	0.17	1.22
2010-2011	0.03	1.10	-0.86	0.03	1.09	-0.91	0.03	-0.67	0.14	1.19
2011-2012	0.01	1.07	-1.02	0.01	1.06	-1.08	0.01	-0.70	0.13	1.19
2012-2013	0.00	1.03	-1.24	0.00	1.02	-1.36	0.00	-0.70	0.13	1.19

Where

QT/MAF= Annual Peak Discharge Over the Arthematic Mean of Annual Flood, QT=Peak Discharge of 'T' years Recurrence interval, YG = Reduced Variate Gringorten, TW = Return Period Weibull, YLM = Reduced Variate L-moment, YW = Reduced Variate Weibull FX = Cumulative Density Function, TG = Return Period Gringorten TLM = Return Period L-moment

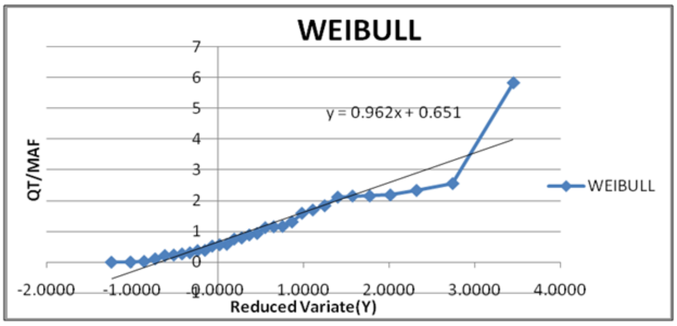

Figure 2: Flood Frequency Curve by Using Weibull Method

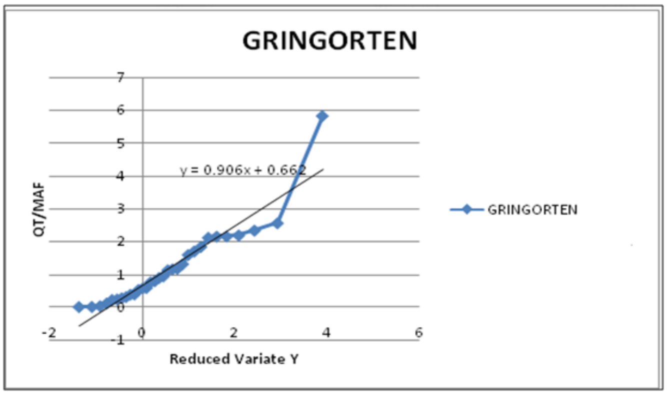

Figure 3: Flood Frequency Curve by Using Gringorten Method

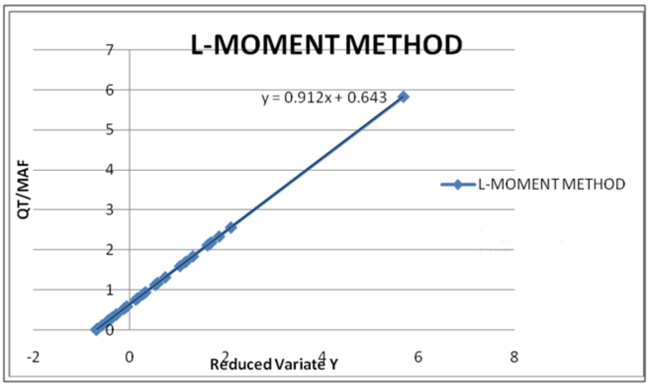

Figure 4: Flood Frequency Curve by Using L-Moment Method

From the graphs it is evident that flood frequency curve of Gumbel distribution by L-moment always fit nicely to probability plot compared to the other two cases

CONCLUSIONS

- In this study, the magnitude and frequency of floods for Krishna river at Prakasam Barrage is analysed using Gumbel distribution with three plotting position formula, namely Weibull, Gringorten and L-Moments. Amongst the three methods, L-moments always give the least ratio of peak discharge
- The flood frequency curve of Gumbel distribution by L-moment always fit nicely to probability plot, because the L-moment gives the less weight to the very high (or) low data values, when compared with other two cases.
- Accurate estimation of flood frequency is needed for the designing of various hydraulic structures such as dam, spillways, barrages etc.;
- The using of extreme value distribution provides estimates of return period for flood peak and flood volume, which could be used as measures of flood protection

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REFERENCES

1. Yerramsetty Abbulu, P.Laxman , V.K.V. Bhadrudu, 2013 *Flood Analysis Of Reservoirs in Visakhapatnam District By Using Probability Methods* International Journal of Civil Engineering (IJCE) ISSN (P):2278-9987; ISSN (E): 2278-9995 Vol.2, Issue5, Nov 2013, 17-24

2. Md. Abdullah Asad, Mohammad Ahmeduzzaman, Shantanu Kar, Md.Ashrafuzzaman Khan, Md. Nobinur Rahman, Samiul Islam *Flood Frequency Modeling Using Gumbel's and Powell's Method for Dudhkumar River.* Journal of Water Resources and Ocean Science, Vol. 2, No. 2, 2013, pp. 25-28.

3. Never Mujere (2011). "Flood Frequency Analysis Using the Gumbel Distribution", International Journal on

4. Computer Science and Engineering (IJCSE) Vol. 3 No. 7 July 2011(2774-2778)

5. Dr. Manas Kumar Mukherjee, 2013 *Flood Frequency Analysis of River Subernarekha, India, Using Gumbel's Extreme Value Distribution* International Journal of Computational Engineering Research||Vol, 03||Issue, 7|| ISSN 2250-3005, July,2013

6. Okonofua Solomon and Ogbeifun Prince, 2013 *Flood Frequency Analysis of Osse River Using Gumbel's Distribution* Civil and Environmental Research www.iiste.org ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online) Vol.3, No.10,2013

7. Subramanya K. (2002). *Engineering Hydrology*, Tata McGraw-Hill, New Delhi

8. Data collected from the Superintending Engineer, Department of Irrigation and Command Area Development (I & CAD**),** Vijayawada Circle

APPENDICES

Table 2: Inflow from 1982-83 to 2012-13 in Cusec

Years	June	July	August	September	October	November	December	January	February	March	April	May	Total
1982-1983	305	3398	194319	84777	55399	44593	14988	10253	7120	4870	11758	19314	451094
1983-1985	5903	5429	548709	491445	335849	23514	4001	5248	2696	5207	13841	15342	1457184
1984-1985	4466	2625	141241	21360	32984	19554	17236	7705	14599	25530	22090	22643	332033
1985-1986	7923	3875	56466	21903	29076	1321	1154	954	0	1212	11043	20360	155287
1986-1987	9559	204	83139	9656	3551	12463	297	2051	3170	10906	140	117	135253
1987-1988	861	11193	4416	601	5167	42226	603	0	0	21227	15574	23997	125874
1988-1989	8652	57423	280606	640533	172314	10351	3124	2895	2185	23169	33521	11096	1245869
1989-1990	9626	128248	96657	192502	176774	10727	16145	9208	13156	14485	19316	60312	747150
1990-1991	22370	16897	427912	166710	171196	36625	25071	28975	46549	54618	37928	11689	1046531
1991-1992	32324	169097	602487	145967	28310	42587	29731	16341	31666	37834	43008	25833	1205185
1992-1993	8109	0	14288	100409	23525	22871	20808	20718	29665	28585	32399	22785	324162
1993-1994	6587	9601	15323	49314	301641	35322	34758	41710	56000	62139	29792	15049	657236
1994-1995	4056	317403	212314	406561	120023	107154	48268	35963	37357	31852	1409	6944	1329304
1995-1996	3116	2106	14182	15251	100163	6170	16733	572	0	0	7504	11005	176802
1996-1997	8777	5395	56611	69025	344654	32440	26966	14799	14595	31860	27366	8143	640631
1997-1998	5340	1762	239569	191914	26287	16860	8018	5677	3484	9090	15136	10011	534148
1998-1999	12090	10142	43034	250205	778946	45234	5935	10991	10187	17349	36585	6199	1226897
1999-2000	11929	30277	144971	56449	26985	6429	7157	1464	3226	11776	23248	9631	333542
2000-2001	18542	22796	140423	6953	4252	4158	3680	102	1613	5873	7901	5011	221304
2001-2002	5575	204	1026	6378	37644	916	0	846	0	2545	7216	2932	65282
2002-2003	1717	0	0	0	564	0	0	0	0	0	0	0	2281
2003-2004	234	0	2553	470	853	0	2183	0	0	0	0	0	6293
2004-2005	0	0	5413	1489	10055	0	0	0	0	0	0	53	17010
2005-2006	0	4385	437415	563250	176119	32749	1339	0	0	2529	4768	2415	1224968
2006-2007	1760	783	768761	132851	39993	21054	383	0	0	0	1689	946	968220
2007-2008	6699	80021	293331	422661	73601	4980	0	0	5222	11439	8552	594	907100
2008-2009	792	1929	118510	154439	5060	9371	7384	73	0	0	1496	525	299579
2009-2010	0	0	1347	1002	495529	3359	0	0	0	0	0	5737	506974
2010-2011	1041	31874	31249	195895	88558	55170	18856	0	579	0	6483	924	430629
2011-2012	282	4549	27221	181627	688	0	157	2220	47	0	0	0	216791
2012-2013	0	4351	22203	183789	138155	294562	0	0	22383	0	0	0	665443